BRIEFER ARTICLES

NEW NORMAL APPLIANCES FOR USE IN PLANT PHYSIOLOGY. V[1]

(WITH TWO FIGURES)

In the preceding articles I have described some ten new pieces of apparatus designed for educational work in plant physiology; accounts of three more are given below, while others are to follow. They are called normal appliances because they are intended to represent the optimum resultant, the harmonic optimum, as it were, between accuracy of results and convenience of use, while at the same time they can always be bought from the stock of a supply company. As in the case of the other pieces these are to be manufactured and sold by the Bausch & Lomb Optical Company of Rochester, N. Y.

X. Space markers

For some purposes, especially in the study of growth, it is necessary to mark off a structure into regular divisions, either areas as in the case of young leaves, or lengths as in roots, stems, or petioles. It is not difficult to improvise appliances for accomplishing these ends, but as yet no tools are available for effecting them quickly, accurately, and conveniently, while at the same time always ready for use. This need, I think, the two little instruments here described will supply.

First, for marking lengthwise, the instrument is a wheel, the rim of which is a rubber stamp having raised cross-lines 2^{mm} apart. It revolves freely but evenly on an axle held in the end of a handle, and when suitably inked by the method described below, it may be run rapidly over long structures such as roots, marking them with narrow black cross-lines equally spaced, precisely as shown at the bottom of *fig. 1*.

Second, for marking areas, the instrument is a disc, likewise a rubber stamp, having raised lines in the form of squares 2^{mm} on a side. It works by means of a scissors-frame against a cushion disc covered with soft felt and provided with a radial slot to admit the petiole of a peltate leaf. When the marking disc is inked and pressed firmly against a leaf held on the cushion disc, it marks a network of even fine black lines like the sample shown in *fig. 1*. The marking disc is hinged to its supporting arm in a

[1] Continued from BOT. GAZETTE **43**:279. April 1907.

way to permit the disc to settle evenly upon the leaf surface no matter what the thickness of the leaf.

Both instruments may be inked from an ordinary rubber-stamp pad, and the black record kind gives good results. Better, however, is a simple

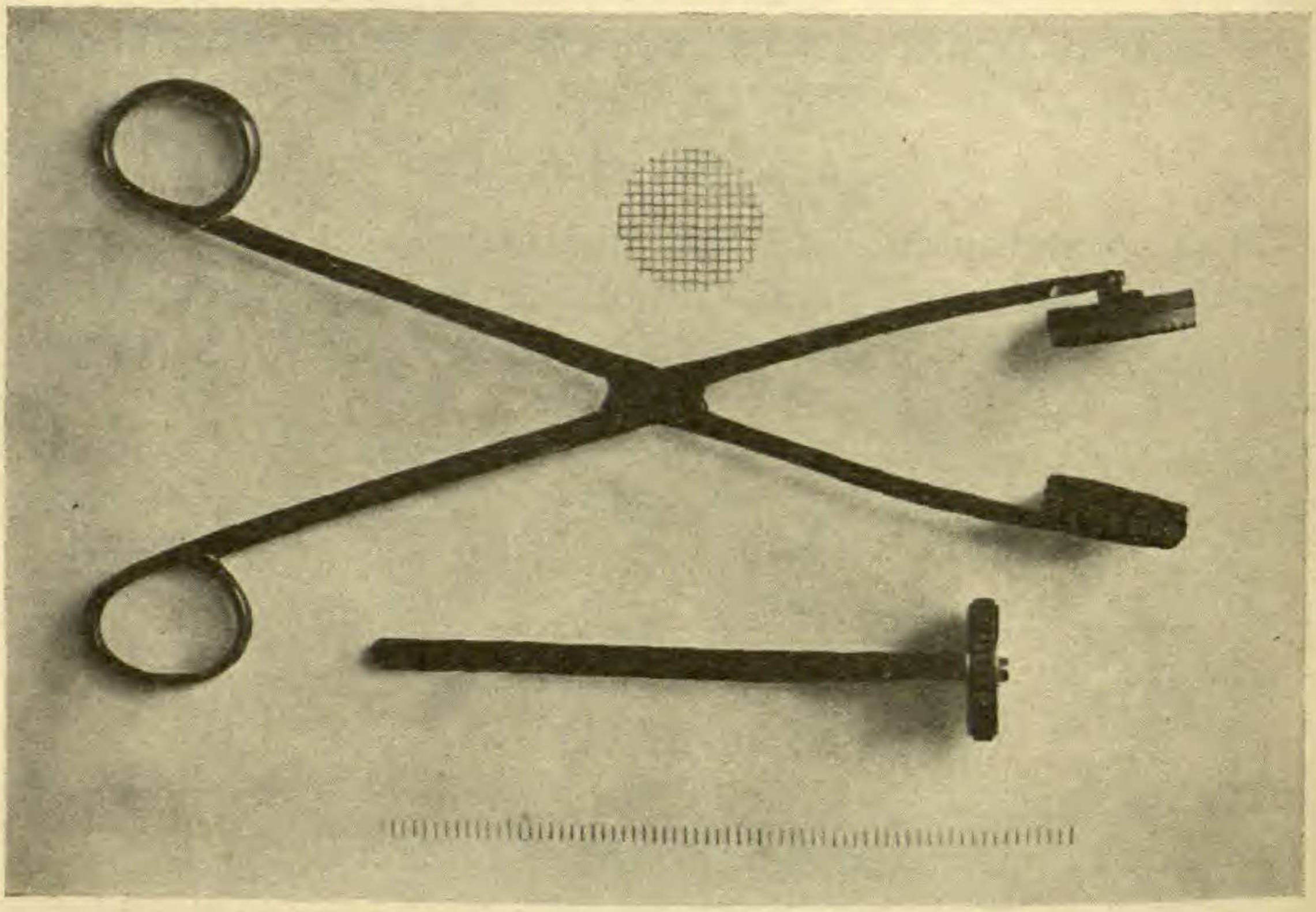

FIG. 1.—Space markers. $\times\frac{1}{2}$.

pad made from one fold of thin close cotton cloth attached by thread to an ordinary glass slide, and inked when needed by a mixture of three parts Higgins' waterproof India ink and one part glycerin.

XI. Demonstration auxograph

Among the most important of the topics which all teachers desire to demonstrate in general botanical courses is growth, and this can be shown to complete satisfaction only through use of a recording instrument. Many recording auxanometers, or auxographs, have been described, but as yet no practical instrument for educational purposes is obtainable by purchase. The essentials of a good demonstration instrument, aside from easy applicability to its work and durability, are reasonable accuracy, ready portability, visibility of record from some distance, and clear exhibition of its mechanism and principle. These ends, I believe, are well met in the instrument here described and illustrated (*fig. 2*).

It consists essentially of four parts: support-stand, recording cylinder, magnifying wheel, and plant-support. The support-stand is of rigid

though thin steel, and is provided with convenient handles, leveling screws, and suitable holes for the two upright rods. The recording cylinder,

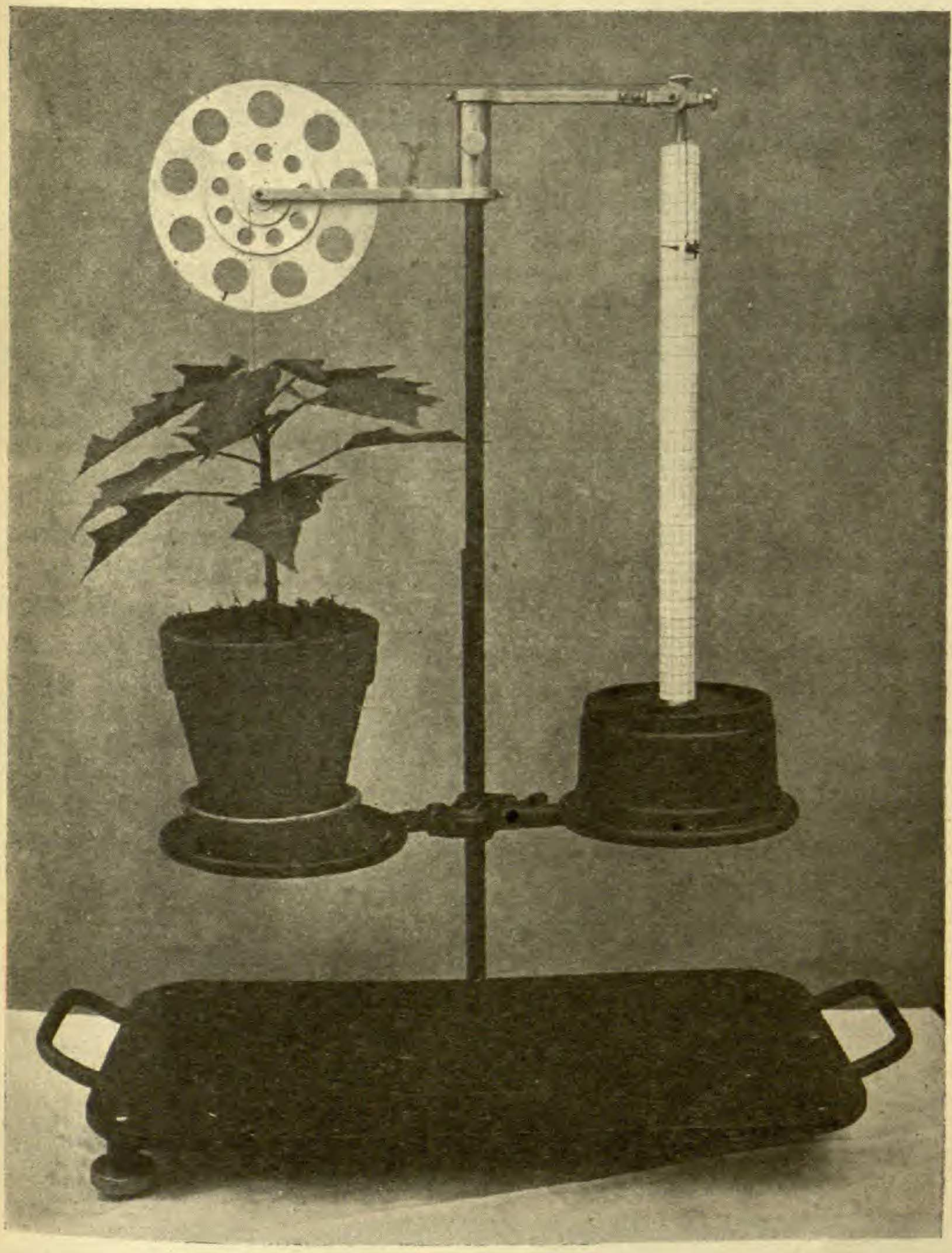

FIG. 2.—Demonstration auxograph. $\times\frac{1}{4}$.

supported and guided at the top by a screw pivot, turns once an hour, and is of such circumference that each millimeter of a millimeter record paper represents one minute. It is carried by a clock which is supported at such

a height that it may be wound and regulated from beneath without disturbing the record. The magnifying wheel, really four concentric wheels combined, allows three degrees of magnification, two, four, and eight times the actual growth. It is made of aluminum, moves on a very sensitive axle, has suitable openings for attachment of threads, and is provided with a clamp for holding it immovable while adjustment of threads and the like is being made. The tip of the plant is brought into action with the wheel by means of a fine thread in the usual way; but in order that this thread may be kept as short as possible, a plant support, adjustable for height, is provided on a separate rod, thus permitting the tip of the plant to be kept close to the magnifying wheel, though, of course, care must be taken to prevent the danger of shading, and hence of phototropic bendings. This adjustable support, however, has another very important use which will be mentioned below. The thread from the large wheel passes over a pulley to the pen carrier, which slides on a fine guide wire and has sufficient weight to turn the wheels in proportion as the growth of the plant permits the small wheel to turn. The pen is of glass, drawn to a capillary point and bent so as to rest at right angles to the paper. It is filled with chrono-graph ink, and, as the plant grows and the cylinder turns, it traces a fine spiral line down the cylinder, crossing any given vertical line once an hour. When this pen has reached the bottom of the cylinder, one has only to put on a new cylinder or record paper, turn the large wheel backward until the pen is drawn to its top, close the clamp to hold the wheel immovable, lower the plant support until the thread from the plant becomes again taut, loosen the clamp to allow the tensions to adjust themselves, and then the record is resumed; and this procedure can be repeated until the end of the experiment without any need for ever touching the threads. This is the other advantage, above mentioned, of the adjustable plant-support. One should never draw up the pen by lowering the plant support, as there is a constant temptation to do, since this brings an unnatural strain upon the plant tip. All parts of the instrument, even to the arms carrying magnifying wheel and pulley, are adjustable, so the instrument may be made to work smoothly under any conditions. While designed primarily for making records of growth, it can be used for any measurements involving movement, e. g., the rise of water in a tube.

The weak point of all auxographs lies in the threads, which will alter length hygroscopically and thus introduce error into the record, despite any known treatment with wax, oil, rubber, etc. These alterations may be minimized by treating the threads with wax, and by keeping them as short as possible, for which reason they should be made only long enough to

allow the turning of the wheels, with no extra turns around the latter. The error, of course, is greatest from the thread attached to the plant, since its alterations of length are magnified in the record. Not only should this thread be kept short, but I think a glass filament could advantageously be substituted for all of its length except the loop at the plant and the partial turn around the wheel. The results of these errors can also be relatively minimized by using plants of the most rapid and vigorous growth, such as the flower-stalks of bulbous plants.—W. F. GANONG, *Smith College, Northampton, Mass.*